PRODUCTIVITY OF LINCOLN SHEEP IN MEXICO

(PRELIMINARY ANALYSIS)

By

ANDRES MOLINA FONSECA

Ingeniero Agronomo Especialista en Zootecnia

Universidad Autonoma Chapingo

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Thesis Approved:

Joe V. Whiteman
Thesis Adviser

D G Wagner

Robert P. Wettemann

Norman N. Durham
Dean of the Graduate College

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CHAPTER I

INTRODUCTION

Sheep in Mexico

The sheep industry in Mexico has decreased greatly during the 20th century. During the first 40 years, the Mexican sheep population went from approximately 16.0 million head down to 4.5 million head. In the last 33 years, the sheep industry in Mexico has been practically static. The Mexican sheep population reached 8.5 million head in the early 1970's, and by 1979 the number of head was somewhere close to 6.0 million (Galina, 1981; DGEA, 1979).

On the other hand, wool and mutton needs have increased in a parallel way with the human population, and importation of these products has been a necessity in Mexico. In 1981, 74,662 sheep, valued at 2.0 million, U.S. Dls., were imported for slaughter, mainly from U.S. and Canada (Galine, 1981), and in 1979, 80% of the wool needs (4,006 metric tons) were imported principally from Australia and Argentina (Flores, 1983).

In response to this situation, the Mexican government is now giving support to the sheep industry in order to increase the quantity and quality of wool and mutton production and to avoid as much as possible the importation of these products.

Why Lincoln Sheep in Mexico

In 1979, a hand-made rug industry was initiated for the purpose of utilizing available labor in an indigent area of the state of Mexico. These rugs were used to compete in the international market. The rugs succeeded in the international market; however, their production depended completely upon the importation of wool from Australia and Argentina. The reason was that Mexican sheep did not produce wool with the desirable characteristics to produce the rugs (fiber diameter, 35 micron minimum; staple length, 110 mm; crimp, .5-2/cm).

The next step taken was to see which breed or breeds produced that kind of wool and which would be the most suitable for Mexican conditions. The actual choice was Lincoln sheep.

Purpose of This Study

Since this is the first time that sheep of the Lincoln breed has been in Mexico as a straight breed and there is little information about Lincoln sheep, this study was initiated to analyze the performance of Lincoln sheep under Mexican highland conditions.

The specific points of this study were to:

1. Estimate birth weight and lamb survival to 90 days of age (weaning). Relationship between these traits were determined as well as the effects of source of dam, birth type and sex.

2. Estimate weaning weight and average daily gain to weaning and determine the effect of source of dam, birth type and sex on these traits.

3. Estimate wool production (weight and staple length) and determine the effect of source of dam, type of parturition and number of lambs reared on these traits.

4. Estimate some measures of reproductive performance.

CHAPTER II

LITERATURE REVIEW

The Lincoln breed of sheep was originated in England from Leicester and Old Lincoln crosses. Some new breeds, containing Lincoln breeding, Columbia, Panama and Targhee, were developed in the United States, and Corriedale was originated in New Zealand. All these breeds have a high percentage of Lincoln blood, 50, 50, 25, and 50%, respectively (American Wool Council, 1982). In all those cases, Lincoln sheep were used to obtain the size and weight of the crossbred lamb, as well as weight and brightness of the fleece (Marshall, 1949).

However, even though the Lincoln breed served as a foundation for new breeds, the information on Lincoln sheep as the experimental breed, is minimal. Only some information about the description of the breed was found. This information describes the body size of Lincoln sheep as the largest of any breed of sheep, with a mature body weight of 113-159 Kg in males and 90-113 Kg in females (Briggs and Briggs, 1913; Scott, 1970; Lessiter, 1976). However, Lincolns have on the average narrow carcasses which lack in quality of lean and carry an excess of external fat (Briggs and Briggs, 1913). The growth rate in a scale from 1 (the lowest) to 5 (the highest) would be somewhere between 2.5 and 3.0 (Scott, 1970; Lessiter, 1976). The degree of hardiness in the same scale would be between 2.0 and 2.5 (Scott, 1970; Lessiter, 1976).

As far as prolificacy, easy of lambing, milking ability, out of season breeding and longevity are concerned, Lincolns are close to the average of the other breeds grown in the United States (Scott, 1970; Lessiter, 1976).

Lincoln fleeces are characterized as having very long (20-39 cm) staple and coarse (41.0-33.5 micron) fibers, which are very lustrous and braided. The weight of the ewe fleeces is somewhere between 5.4-9.0 Kg and yields between 36 to 46 hanks of yarn for each pound of wool top (American Wool Council, 1982).

This review is divided into the following topics: (a) breeding season of sheep; (b) reproductive performance of different breeds of sheep; (c) lamb survival, birth weight and growth patterns in sheep; and (d) effect of different factors on wool production.

Breeding Season of Sheep

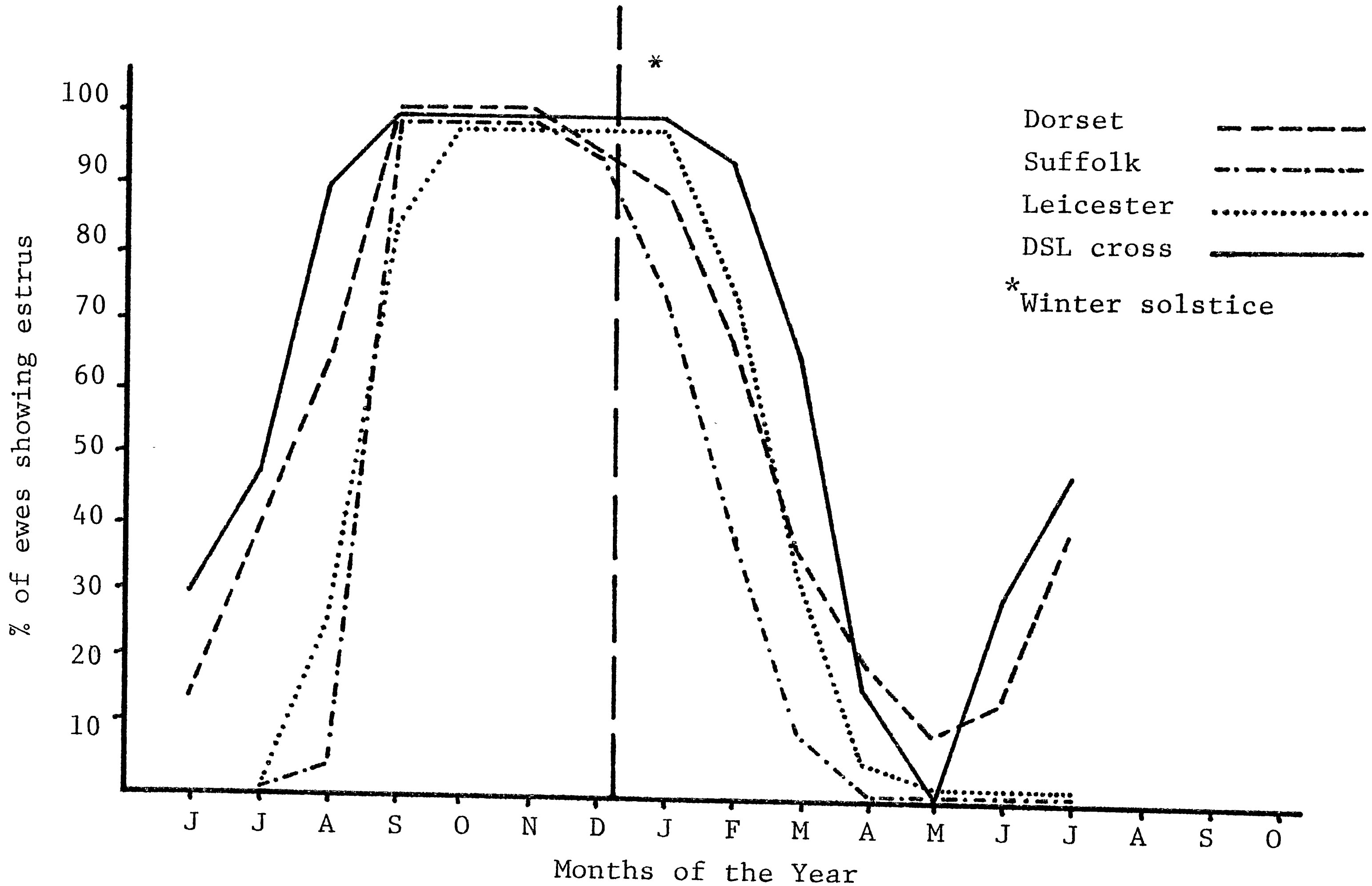
In general most sheep have a well defined breeding season and also a well defined period of anestrus. In general, maximum sexual activity occurs in the autumn and early winter months (on the average prior to the shortest day of the year) irrespective of the hemisphere (Hafez, 1952). Sheep and goats in the wild show differences in the length of the breeding season. In general, the breeding season gets shorter as sheep and goats get closer to the polar areas. This seems to be in close relation with length of the day and supply of food for the newborn individual (Yeates, 1949). A longer breeding season is reached with a high degree of domestication (selection and more constant feed supply). However, in domestic sheep, the breeding season, which is related to the seasonal day-length changes, gets gradually shorter as the latitude of the location increases (Hafez, 1952). Moving sheep from one hemisphere to the other affects the ovarian activity of the sheep. Yeates (1949) suggested that these changes were affected more than anything else by the time of the year when the transfer of the ewes was done. It could be said that if the change is when ewes are cycling or they are in early pregnancy, then two lambing times within a year could be expected. On the other hand, if ewes are in the anestrous period, then ewes could remain open for an unnecessary longer time.

Whitehurst et al. (1947) realized that reproductivity of Columbia sheep was lower when sheep were moved from Dubois, Idaho (45 degrees north latitude) to Quincy, Florida (33 degrees north latitude). It took two years for the sheep after moving to Florida to reach similar reproductive performance as similar ewes in Idaho. Hafez (1952) reported that Blackface sheep of Scotland, which are believed to have two estrual cycles per year, experienced six estrual cycles when transferred to the plains of northern France. At the Equator, where there is no fluctuation in the hours of day light, or in low latitudes, the breeding season may be extended over the whole year (Hafez, 1952). However, it seems that most ewes have an anestrous period during the year which could be related to rainfall, food supply, temperature, breed or some other management factors (Hafez, 1952).

Variation in the estrual activity of domestic sheep has been shown among breeds at the same location, within breeds at different locations and within a breed at the same location.

Duffour (1974) found differences in the estrual activity of Suffolk, Leicester, Dorset and the crossbred line of the three breeds in Canada. Variation was observed at the onset of the breeding season as well as at the end of the season. However, the crossbred line had the longest breeding season. The season began earlier and ended later than that of purebreeds (Figure 1). In these cases, the midbreeding season occurred before the shortest day of the year, which is in agreement with Hafez (1952).

In a similar study, Wheeler and Land (1977) working with Finnish Landrace, Tasmanian Merino and Scottish Blackface, under central Scotland conditions, found differences in estrual activity among those breeds. In these cases, the mid-breeding season occurred before the shortest day of the year for Tasmanian Merino, coincided



Source: Duffor, J. J. (1974).

Figure 1. Estrual Activity of Dorset, Suffolk, Leicester and a Cross-Bred of the Three Breeds Under Canadian Conditions

almost with the shortest day of the year for Scottish Blackface and was after the shortest day of the year in the case of Finnish Landrace (Figure 2). Oestrous cycle tended to be shorter at the beginning of the breeding season and longer at the end of the breeding season. Ovulation rate was also measured and was found to vary widely among breeds. Finnsheep had three single ovulations out of 128, whereas Merinos only had 15 multiple ovulations out of 205 cases.

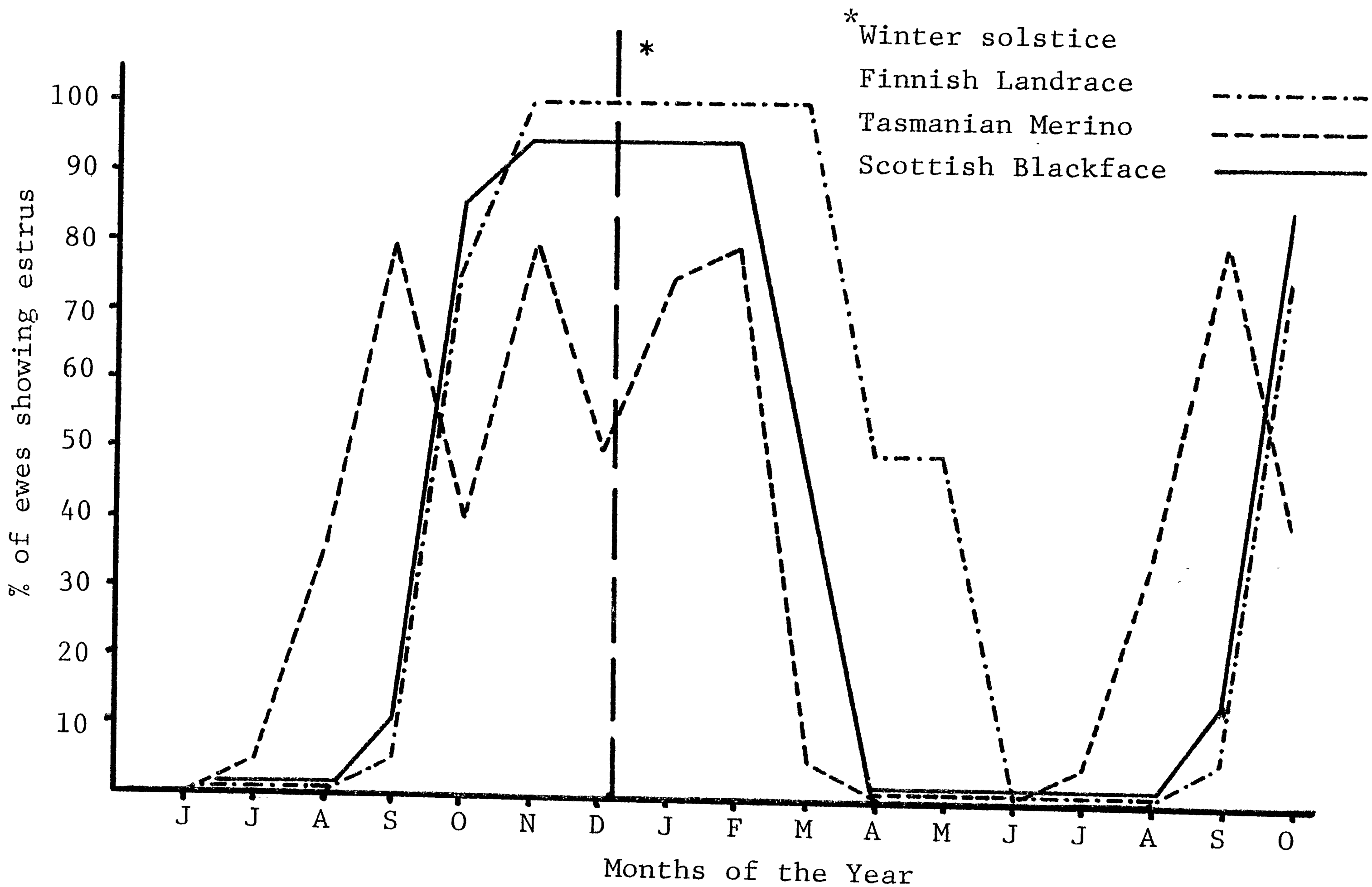
Wiggins, Barker and Miller (1970) described the estrual pattern of Rambouillet sheep under Auburn, Alabama conditions (Figure 3). They found, within a selected group of animals, three different patterns. Fifteen percent of the ewes showed estrus throughout the year, 48% had a well defined estrual and anestrual seasons, and 36% had two estrual and two anestrual periods within a single year.

Mallampati, Pope and Casida (1971) realized that Targhee sheep in Wisconsin had a breeding season of about 23 weeks, which is similar to that of many British breeds with medium length breeding season (Lincoln, Romney, Marsh, etc.).

In this case (Figure 3) the mid-breeding season occurred before the winter solstice day.

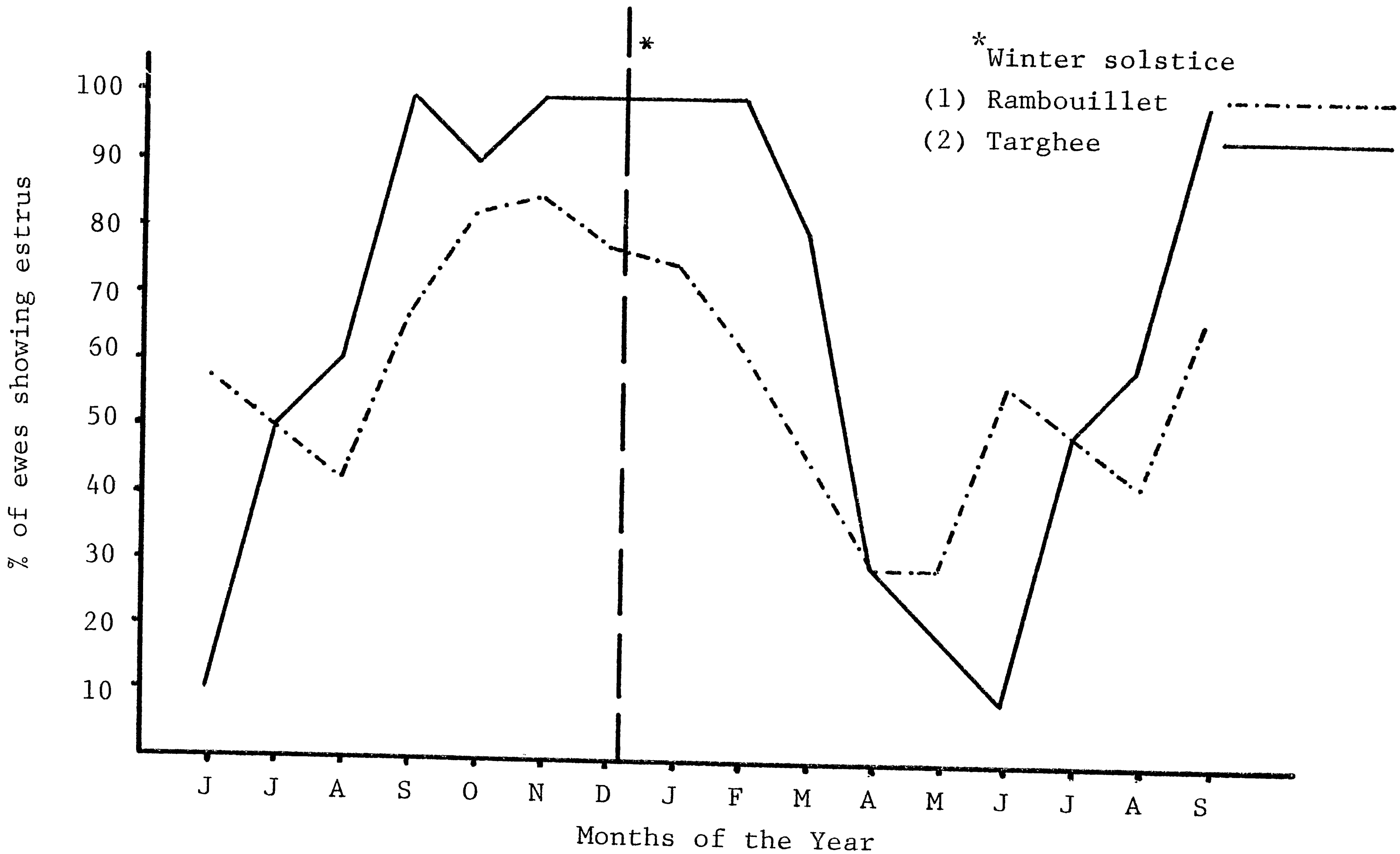
It can be seen (Figures 1, 2, and 3) why one breed can be considered more an out of season breed than others.

Some researchers considered the average week of the first estrus as good point to start the breeding season. Based on that idea McKenzie and Phillips (1930), using



Source: Wheeler and Land (1977).

Figure 2. Estrual Activity of Finnish Landrace, Tasmanian Merino and Scottish Blackface Under Central Lowlands of Scotland



Source: (1) Wiggins et al. (1970); (2) Mallampati et al. (1971).

Figure 3. Estrual Activity of (1) Rambouillet Ewes in Auburn, Alabama and (2) Targhee Ewes in Wisconsin

Hampshire, Shropshire and Southdown sheep under Missouri pasture conditions, suggested that this point was reached in late August or early September. The Hampshire breed started cycling about 10 days ahead of the other breeds.

Scott, Phillips and Spencer (1939) reported that under Maryland conditions, Corriedales reached the average week for the first estrus somewhere between August 29 and September 4. The Hampshire, Shropshire and Southdown breeds began cycling between September 12 and September 18. Karakul and Karakul X Corriedale ewes reached this point between September 5 and September 11, and Karakul X Blackface Highland between September 12 and September 18. They said also that the yearling ewes tended to have their first estrus later than the mature ewes.

Cole and Miller (1935), with the same system, stated that for Rambouillet and Rambouillet X Romney, the breeding season began in early July and early August respectively.

McKenzie and Terrill (1937) said that the breeding season for Hampshire, Shropshire, Southdown, Rambouillet and grade animals in Missouri, usually is extended from September to January.

This information gives the tendency of estrual behavior of different breeds of sheep in the north hemisphere.

About the southern hemisphere, Kelley and Shaw (1943) showed, wotking with Border Leicester and Dorset, that the sexual behavior is similar to that showed in the north hemisphere, with a six month difference. Moreover, in both breeds, the period of greatest sexual activity in one of the hemispheres corresponded to the period of lowest sexual activity in the other hemisphere.

Reproductive Performance of Different Breeds of Sheep

Reproductive performance varies between breeds, and production system used. Brandford and Boylan (1981) working with purebred sheep under Minnesota farm conditions found that the percentage of ewe lambs lambing at 12 months of age had a large variation (Table I). Suggesting that precocity is a characteristic of each breed that could be affected by environmental factors such as nutrition.

TABLE I

FERTILITY OF EWE LAMBS OF DIFFERENT BREEDS UNDER MINNESOTA CONDITIONS

Breed	No. Ewe Lambs	% Lambing
Finnsheep	53	95.0 ± 4.5
Minnesota 100	67	74.1 ± 4.0
Suffolk	82	90.0 ± 3.6
Targhee	40	51.4 ± 5.2

Source: Brandford and Boylan (1981).

Huston (1983) working with 83 Rambouillet ewes on year long rangeland in west Texas, reported 88% of ewes lambing per year with a twinning frequency of 31%.

Galina et al. (1982) working with Suffolk under central Mexico farm conditions found different reproductive estimates when using different breeding season periods (Table II). They suggested that in those conditions, reproductive performance of Suffolk sheep is better when mated early in the breeding season.

TABLE II

SOME REPRODUCTIVE TRAITS OF SUFFOLK SHEEP AT TWO DIFFERENT BREEDING PERIODS UNDER MEXICAN HIGHLAND CONDITIONS

Traits	Breeding Season Periods Aug. 18-Sept. 18	Breeding Season Periods Nov. 15-Jan. 15
Ewes lambing (fertility) (%)	80.0	67.6
Prolificacy (%)	128.7	108.0
Age at first breeding (mo)	9.0	18.0
Twinning frequency (%)	37.0	8.4

Source: Galina et al. (1982).

Notter and Copenhaver (1980) in Blacksburg, Virginia, compared the performance of Finnish Landrace crossbred ewes under accelerated lambing on a five year period, lambing three times every two years. They reported that conception rate was the highest in August (90 ± 3%) and was similar for ½ Finnish Landrace, ¼ Finnish Landrace and the cross Suffolk X Rambouillet. When the breeding season was in November, conception rate was 79 ± 4% and similar for all the breed groups. In the case of April mating, conception rate was lower (53 ± 3%) and was different for each breeding group of sheep (65 ± 5% for ½ Finnsheep, 45 ± 4% for ¼ Finnsheep and 38 ± 7% for Suffolk X Rambouillet).

When the breeding season was in August or November, conception rate was 5% lower for those ewes that had lambed two to four months before, than for the ones that lambed seven months before. However, when the breeding season was in April, concpetion rate was 23% higher for ewes that had lambed two to four months before than those that lambed at least seven months before, suggesting that ewes on an out of season breeding program are more prone to be mated when they lambed in the last normal breeding season than if they failed. Average conception rate and litter size were maximized at about five years of age.

This work summarizes the effect of information of a new breed in the performance of the new individuals. In this situation, ½ Finnsheep ewes had .48 more lambs per litter than ¼ Finnsheep, and .50 more lambs than Suffolk X Rambouillet. Also ½ Finnsheep produced at weaning 30% more lambs and 12% more Kg of lamb than ¼ Finnsheep, and 41% more lambs and 17% more Kg of lamb than the crossbred Suffolk X Rambouillet.

Flinn and Whiteman (1974) in Oklahoma, reported that Dorset rams performed better than blackfaced rams ($P < .025$) when used for spring breeding season; however, blackfaces performed better than Dorset rams ($P < .005$) when used for fall breeding season. The same study reported a better performance of the triplecross than the backcross mating in regard to lambing rate (5% more, $P < .20$), lamb mortality (3.3% less, $P < .075$), lambs reared (9.3% more, $P < .025$) and lamb vigor (7.0% more strong lambs, $P < .01$). This suggests an increase in viability of the embryo and/or fetus, and viability and vigor in the new born of the triplecross probably due to heterosis effect.

Whiteman et al. (1972) using Dorset, Rambouillet and Dorset X Rambouillet under Oklahoma conditions and in a twice a year mating program, reported a very low conception rate (35%) for spring (April 20-June 18) breeding as compared with 84% for fall (October 20-December 18) breeding over a period of five years.

Walton and Robertson (1973) using a small flock of Finnish Landrace ewes maintained under eastern Canada conditions (45 degrees north latitude) on a summer grazing and winter indoor hay-feed system and a twice yearly mating program, reported that 33.3% of the ewes conceived at each of the five breeding periods, and 72.2% conceived at least four times. Of the 172 ewe exposures, during the five consecutive periods, 146 conceptions (84.9%) occurred, producing 305 lambs. The mean lambing rate was 1.77 lambs per ewe exposed, equivalent to a mean lambing rate of 3.54 lambs per ewe exposed for a 12 month period. The breeding periods were: Fall 1969 (Aug. 10-Nov. 30), Spring 1970 (Jan. 5-Apr. 30), Fall 1970 (Aug. 3-Nov. 30), Spring 1971 (Jan. 15-Apr. 30), and Fall 1971 (July 11-Nov. 30).

Sidwell et al. (1962) working with Hampshire, Shropshire Southdown, Merino and one strain of Columbia-Southdale cross under the pasture conditions of Beltsville, Maryland, reported that fertility, prolificacy, lamb livability and their combination in percent of lambs weaned of ewes exposed to ram, were on the average higher for crossbred than for purebred matings. Also there was an upward trend with an increase in the number of breeds involved in the crosses (Table III). Even in fertility, where there was no significant difference, there was a tendency for an increase as number of breeds involved in the cross increased. The percentage of lambs weaned of ewes exposed was considered the best single measure of the lamb productivity ability of the flock. It includes the other three characteristics.

Thrift and Whiteman (1969) reported that Dorset crossbred ewes perform better than Western ewes under a fall lambing program. Dorset ewes had a higher percentage of ewes lambing (7.7%, $P < .10$), larger lambing rate (.19 lambs more, $P < .005$) and a greater percentage of lambs reared per 100 ewes (22.6%, $P < .01$).

In general, the tendency to lamb out of season is primarily controlled by the genetic makeup of the breed

TABLE III

FERTILITY, PROLIFICACY AND LAMB LIVABILITY OF PUREBRED AND CROSSBRED MATINGS

Type of Mating	Fertility % of Ewes Lambing of Ewes Exposed	Prolificacy % of Lambs Born of Ewes Lambing	Lamb Livability % Lambs Born Alive of Total Lambs	 % Lambs Weaned of Lambs Born Alive	Overall Reproduction % Lambs Weaned of Ewes Exposed
Pure breed	88.0	137.3[b]	93.2[a]	80.4[a]	89.5[a]
2-breed cross	88.6	128.4[a]	94.9[ab]	84.1[ab]	91.4[a]
3-breed cross	90.0	147.6[c]	95.4[ab]	84.0[ab]	103.5[b]
4-breed cross	92.3	149.0[c]	97.0[b]	89.4[b]	117.2[c]

[abc]Means with different letter in the same column differ significantly ($P < .05$).

Source: Sidwell et al. (1962).

(effect of out of season breeds). On the other hand, the increment in lambing rate and number of lambs reared could be due to heterosis effects.

Lamb Survival, Birth Weight and Growth Patterns in Sheep

Brandford and Boylan (1981), under Minnesota farm conditions, reported differences among breeds in survival percentage from birth to weaning. The survival rates obtained were 88.9 ± 2.5% for Finnsheep, 77.1 ± 1.5% for Targhee, 69.3 ± 2.6% for Minnesota-100, and 66.7 ± 2.3% for Suffolk.

Huston (1983) reported a 75% survival from birth to 90 days weaning for Rambouillet lambs on range land in West Texas.

Galina et al. (1982), working with Suffolk in Mexico, reported a percentage of lamb survival at 15 days of 93.4% for those lambs born in January to March, and 87.4% for those born in April to June.

Survival within breeds have a variation that seems to be related to birth weight variation.

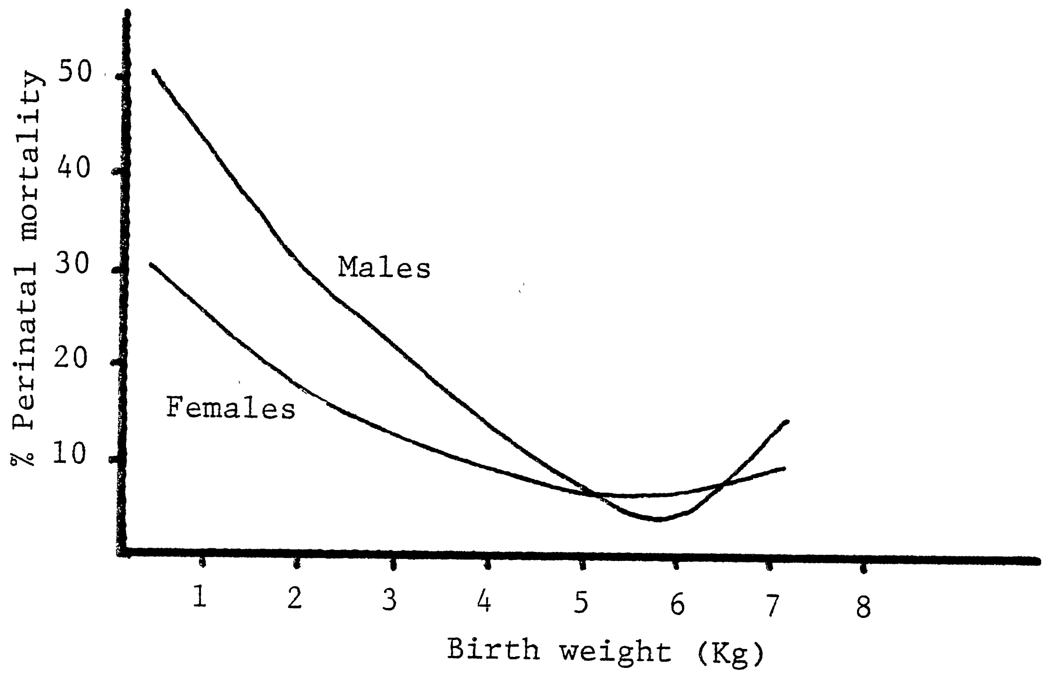
Notter and Copenhaver (1980), when working with Finnsheep crossbred ewes under accelerated lambing in Blacksburg, Virginia, observed that there was a quadratic effect of birth weight on perinatal mortality. Males perinatal mortality appeared to be larger than females perinatal mortality, especially when the new born lambs were light (Figure 4). However, this was merely a tendency since there was no significant difference. In both cases the optimum birth weight was between 5.0 and 6.0 Kg.

Brandford and Boylan (1981) working with Finnsheep, Minnesota-100, Suffolk and Targhee breeds under Minnesota farm conditions, found that in general as number of lambs increased, the birth weight decreased and the percentage of survival from total lambs born also decreased (Table IV). However, it was observed that on the average, even though females (3.19 ± .14 Kg) were lighter than males (3.47 ± .14 Kg) the percentage of survival was higher for females (75.5 ± 1.0%) than males (74.5 ± 1.0%). These differences were not significant. When they looked at the age of the dam, they found that in general as age of dam increased until five years, birth weight and percentage of survival of their lambs also increased (Table V).

Magid et al. (1981a, b) working with Border Leicester and Finnsheep crosses at Clay Center, Nebraska, observed differences among breeds in the estimates of birth weight and lamb survival.

However, the tendencies of birth weight and lamb survival in regard to birth type, sex and age of dam were similar.

Hazel and Terrill (1945) working with Rambouillet lambs under intermountain range conditions of the western United States, found that on the average males at weaning were 3.76 Kg heavier than females, and single-born lambs



Source: Notter and Copenhaver (1980).

Figure 4. Relationship Between Perinatal Mortality and Birth Weight in Male and Female Lambs

TABLE IV

VARIATION OF SURVIVAL RATE AND BIRTH WEIGHT OF LAMBS WITH DIFFERENT TYPE OF BIRTH

Type of Birth	% Lamb Survival of Total Born	Birth Weight (Kg) Dev. from Mean*
Single	89.1 ± 1.2	1.33 ± .06
Twins	75.7 ± 0.9	0.42 ± .06
Triplets	74.7 ± 2.1	-0.26 ± .06
Quadruplets	61.9 ± 5.4	-0.44 ± .10
Quintuplets	71.5 ± 11.9	-1.05 ± .18

*The estimation of the mean of birth weight was 33.3 ± .01 Kg. Positive numbers indicate amount above the mean estimated. Negative numbers indicate amount below the mean estimated.

Source: Brandford and Boylan (1981).

TABLE V

VARIATION OF SURVIVAL RATE AND BIRTH WEIGHT OF LAMBS BORN FROM EWES OF DIFFERENT AGES

Age of Dam (Years)	% Lamb Survival of Total Born	Birth Weight (Kg) Dev. from Mean*
1	61.7 ± 1.3	-.67 ± .33
2	77.9 ± 1.4	-.24 ± .31
3	80.0 ± 1.8	.18 ± .40
4	81.9 ± 1.9	.24 ± .05
5	73.7 ± 1.7	.49 ± .06

*The estimation of the mean of birth weight was 33.3 ± .01 Kg. Positive numbers indicate amount above the mean estimated. Negative numbers indicate amount below the mean estimated.

Source: Brandford and Boylan (1981).

were at weaning 4.17 Kg heavier than twin-born lambs. Also lambs born from mature ewes were at weaning 2.76 Kg heavier than lambs from 2-year old ewes, having an average weaning weight of 31.29 Kg.

In a similar study, Hazel and Terrill (1946) working with Columbia, Corriedale and Targhee found a similar pattern of differences. However, the differences at weaning in this later study were 4.89 Kg in favor of the males, 5.30 Kg more for the singles than the twins and 3.94 Kg heavier for those lambs that came from mature ewes than those from 2-year ewes. The average weaning weight at 120 days was 33.11 Kg.

Terrill et al. (1947, 1948) woking with Columbia and Targhee breeds reported that single yearling Columbia ewes weighed 3.22 Kg more than the twins and the single yearling Targhee ewes weighed 2.13 Kg more than the twins. Age of dam had a big effect on Columbias (1.88 Kg heavier than those ewe lambs born from mature ewes); however, in Targhee, this effect was not significant. The average yearling weights were 39.82 Kg for Columbias and 35.29 Kg for Targhee. In the case of rams, age of the dam had the same effect. Columbia ram lambs born from mature ewes weighed 3.58 Kg more than those born from 2-year ewes. Targhee breed did not show a significant difference in ram lambs at weaning. Type of birth also had a greater effect in Columbias than in Targhees. Single yearling Columbia rams averaged 3.22 Kg heavier than twin rams. Targhee differences were very small. The average yearling weight for rams were 56.74 Kg for Columbias and 53.11 Kg for Targhees.

Blackwell and Henderson (1955) working with Dorset (D), Hampshire (H), Shropshire (S) and Corriedale (D) sheep under farm conditions at Cornell University, found that birth weight and weaning weight varied in the same way as Terrill et al. (1945, 1946) reported for Rambouillet range lambs. The birth weight averages for these breeds were 4.35, 4.08, 3.35, and 3.31 Kg for (H), (C), (D), and (S) respectively. On the average males at birth were .24 ± .03 Kg heavier than females and single born lambs at birth were .84 Kg heavier than twin born lambs. At weaning the average weights of the breeds were 32.20, 28.66, 27.98, and 25.04 Kg for (H), (D), (C), and (S) respectively, and males and single born lambs were 1.98 and 3.75 Kg heavier than females and twin born lambs respectively.

DeBaca et al. (1956), working with Suffolk and Southdown sired lambs out of Hampshire, Border Leicester, Cheviot and Romney crossbred ewes under the commercial hill pasture areas of western Oregon, found similar effects of birth type, and sex on weaning weight at 120 days. However, they said that the main factor in the variation of weaning weight was birth weight. The authors found that the range of increase in weaning weight varied from 1.13 ± .29 to 2.70 ± .34 Kg for each Kg of increase in birth weight.

Sidwell et al. (1964) working with Hampshire, Shropshire Southdown, Merino and one strain of

Columbia-Southdale cross under the pasture conditions of Beltsville, Maryland, found that birth weight was affected by sex, birth type and age of the dam. On the average, the birth weight of males was greater than that of females (3.72 and 3.49 Kg respectively, $P < .05$). Single born lambs at birth weighed more than twin born lambs (4.18 and 3.27 Kg respectively, $P < .05$), and lambs out of ewes four or more years old were heavier than those out of three year old ewes, and those in turn were heavier than the ones out of two year old ewes (3.79, 3.57, and 3.29 Kg respectively, $P < .05$).

Considerable differences in the average birth weight were evident from year to year. However, the general pattern of birth weight affected by sex, birth type and age of the dam remained similar.

When observing the differences between purebred and crossbred lambs, Sidwell et al. (1964) found that on the average crossbred lambs were heavier at weaning than purebred lambs by 3.17 Kg (26.39 and 23.22 Kg respectively). Crossbred lambs showed an advantage of 2.94 Kg in gain from birth to weaning (22.77 and 19.82 Kg respectively). Least-squares means for both birth weight and weaning weight ranked the breeds in the following order: Hampshire, the highest; followed by Columbia-Southdale, Shropshire, Merino, and Southdown.

Eltawil et al. (1970) found that environmental factors such as type of birth and rearing, sex, age of dam and year of birth had a highly significant effect on birth weight, weaning weight and yearling traits when working with Navajo sheep under southwestern New Mexico range conditions (Table VI). In general, birth weight and weaning weight increased as the number of born lambs decreased; birth weight and weaning weight increased as age of dam increased; and, on the average, males were heavier than females in both stages.

TABLE VI

BIRTH WEIGHT AND WEANING WEIGHT MEANS OF NAVAJO SHEEP BY TYPE OF BIRTH AGE OF DAM AND SEX

Traits	Birth Weight	Weaning Weight
Type of Birth		
Singles	3.99 ± .01	26.99 ± .12
Twins	3.23 ± .01	20.73 ± .14
Age of Dam		
2 years	3.21 ± .03	25.81 ± .17
3 years	3.51 ± .03	23.70 ± .17
4-7 years	3.74 ± .02	25.08 ± .15
7 or more years	3.98 ± .06	24.81 ± .12
Sex		
Males	3.71 ± .01	25.15 ± .07
Females	3.51 ± .01	22.87 ± .07

Source: Eltawil et al. (1970).

Lindahl et al. (1972) working with Finnsheep cross lambs under artificially reared Maryland farm conditions, found an ADG at 102 days of .26 ± .03 Kg for ewe lambs and .28 ± .05 Kg for ram lambs. This difference was not significant. However, in 1970, a similar, yet stronger tendency appeared. At that time, rams showed an ADG of .30 ± .05 Kg which was significantly ($P < .01$) greater than females which showed .21 ± .02 Kg.

Gould and Whiteman (1971) working with Dorset, Rambouillet and Dorset X Rambouillet in Oklahoma, reported that lambs performed differently when born in spring or fall. Birth weight was heavier in spring born lambs (4.3 ± .06 Kg) than fall born lambs (3.36 ± .09 Kg). Average daily gain from birth or 70 days was greater for lambs born in the spring (.330 ± .001 Kg) than for those born in the fall (.300 ± .002 Kg). On the other hand, average daily gain from 70 days to market (42.2 Kg) was better for fall lambs (.240 ± .003 Kg) than spring lambs (.180 ± .05 Kg). Fall born lambs reached market weight 6 days younger than spring born lambs. All these results are in agreement with those reported by Notter and Copenhaver (1980). They said that lambs born in September were lighter (3.96 ± .07 Kg) than those born in April (4.57 ± .08 Kg). They also found that preweaning growth was affected by season and sex. Males grew 5% faster than females and were 6% heavier at 45 days of age.

In later work, Stritzke and Whiteman (1982) found a different pattern of lamb performance when born in summer (June-July), fall (October-November) or winter (January-March). Winter born lambs required 30 days less to reach market weight (45.5 Kg) than summer born lambs and 16 days less than fall born lambs. There were differences in birth weight due to season. Winter born lambs (4.78 ± .08 Kg) were .33 Kg heavier at birth than summer born lambs (4.45 ± .08 Kg) and 1.28 Kg heavier than fall born lambs (3.50 ± .08 Kg). These data also confirmed the influence of sex and type of birth on birth weight. Nevertheless, the magnitude of these effects during the different seasons were similar.

Effect of Different Factors on Wool Production

Type of pregnancy and type of rearing in Corriedale and Romnelet ewes in Canada have an effect on wool weight and certain characteristics of the wool, such as fiber length and thickness (Clen and Whiting, 1956). However, they also said that these effects can be reduced by adjusting the nutritional regime of gestating and lactating ewes. With two different levels of protein in the ration, they found that single lamb producers yielded 19% more clean wool than those which produced twins, when ewes were in the low level of protein. On the other hand, this difference was reduced to 11%, which was not significant, when ewes were on a higher protein ration.

Ray and Sidwell (1964) working with old Navojo ewes, coarse-wooled Navajo crossbred, fine-wooled Navajo crossbred, Targhee and four groups of graded up reservation ewes, reported that wool production decreased as reproductive rates increased. Ewes which gave birth to twins, singles or no lambs, produced 2.97, 3.19, and 3.52 Kg of grease wool and 1.52, 1.59, and 1.77 Kg of clean wool respectively. Dry ewes produced significantly ($P < .01$) more grease wool and more clean wool than ewes nursing twin or single lambs. In general, the effects of lactation were greater than those of gestation on reducing wool production. These results are in agreement with the previously mentioned study by Slen and Whiting (1956).

Thrift and Whiteman (1969) studying Western and Dorset X Western ewes under Oklahoma farm conditions, reported that Dorset crossbred ewes produced about the same amount of grease and clean wool regardless of the number of lambs born and/or reared. In the case of Western ewes, in general, the yield of clean wool declined slightly as number of lambs born and reared increased. In regard to age of the ewes, the fleece weight declined as age increased. This was more evident for Western than for Dorset crossbred ewes.

Drummond et al. (1982) working with Rambouillet, Targhee, Columbia and crossbreds of Finnsheep X the other breeds on Montana range conditions, reported that wool length decreased and fiber diameter increased as age increased.

Most of these results indicate that wool records should be adjusted, when possible, before they are used in a selection program.

CHAPTER III

MATERIALS AND METHODS

The introduction of a new breed of sheep in Mexico, and the purchase of the brood stock from different places and at different times (United States, October 1980, and Australia, November 1980), created a special situation that has to be considered when looking at this analysis.

A management program was developed before the sheep came to Mexico. However, Mexican conditions and experiences with the sheep, have made necessary the creation of a modified management program which has had several changes during its development.

Even though several changes have occurred, the people in charge of the sheep station have tried to record all the data possible according to their possibilities, and now in this study an effort has been made to analyze these data in order to understand the performance of Lincoln sheep under Mexican highland conditions.

Most of the changes which occurred are explained in the body of this chapter.

Station Area Description

The station is located close to Jilotepec, a town in the northwest part of the state of Mexico within the physiographic region called Meseta Central. This place is at approximately 19.5 degrees north latitude and is 2,400 meters above sea level.

The climate, according to Koeppen, is subhumid temperate, C(WZ)(W)B(1')G, with an average temperature of 18.6° C and a rainfall of approximately 810.2 mm per year. July to September is considered the rainy season (80% of the total rainfall). November to March is the dry period (6% of the total rainfall). The rest of the precipitation is distributed irregularly throughout the rest of the year.

The station has 20 hectares. Seven of them have introduced grasses under irrigation and 12 (dry land) are used to produce annual forages. The rest of the land houses facilities to manage the sheep. The land is practically flat and is well drained. The soil is the deep black clay type (Flores, 1983).

Flock Composition and Management Procedures

The breeding flock was established with 298 Lincoln ewes and 26 Lincoln rams. Two hundred ewes and 11 rams were imported from an area near Portland, Oregon, U.S.A. and arrived in Mexico in early October of 1980. These sheep had 5 months wool on and all the ewes were non-pregnant and having estrous cycles. The sheep from Australia (98 ewes and 15 rams) came just shorn and arrive in Mexico in early November (11-08-80); however, they were not moved to the station until early December. All the Australian ewes were also non-pregnant. The sheep from the U.S. were in acceptable body condition; however, the sheep from Australia were in fairly thin condition.

The current management is described in Table VII; however, some of the practices described in the table were altered from a previous plan and are explained in detail in the specific descriptions.

TABLE VII

MONTHLY MANAGEMENT CALENDAR

Activity	S	O	N	D	J	F	M	A	M	J	J	A	S	O
Breeding season	X	X											X	X
Lambing season						X	X							
Weaning									X	X				
Lamb sale		X	X											X
Shearing				X	X									
Dipping					X	X								
Drenching	X			X			X			X			X	
Vaccination		X							X					X

Breeding Season

Since all the animals were non-pregnant upon arrival in 1980, the breeding season started as soon as animals arrived to the station, this means October for U.S. ewes and

December for Australian ewes. All the ewes were exposed to all rams. In the second year (1981), the breeding season started in September and lasted until the end of December. In 1982, most of the ewes were bred during September and October (see monthly management calendar).

Starting with the second breeding season, ewes were sorted into three different groups by wool characteristics. The best one third ewes (heaviest and longest fleeces) were mated to the best rams (heaviest and longest fleeces). With the other two thirds, complementary practices were used. The shortest fiber ewes were mated with the longest fiber rams and the thinnest fiber ewes were mated to the coarsest fiber rams. After 35 days of the breeding season, all the ewes were placed together and only the best rams were left with the ewes to finish mating the ewes that were still cycling.

Shearing Time

In the current management program, shearing is done between one and two months before the start of the lambing season. However, since the ewes came in different stages of wool (Americans with five months of wool on and Australians just shorn) the first two years were used to adjust these differences, giving enough time to get the desired length of the wool. The U.S. group had their first shearing in the spring of 1981 (March-April). After that, the complete flock was shorn at the same time. These times were fall of 1981 (September-October), fall 1982 (late October-November), and winter 1983-84 (early January).

Dipping

External parasites were controlled by dipping the ewes around ten days after shearing. When special cases appeared, ewes were given a second bath approximately two weeks later.

Lambing Season

The lambing season varied due to the breeding season; however, in 1984, most of the lambs were born within February and March. The management procedures in the lambing season were:

a. Just after parturition ewe and lamb or lambs were placed in separate lambing pens (1.50 X 1.20 X 0.90 m) for approximately three days, then they were placed in larger pens with the rest of the ewes that have already lambed.

b. Umbilical cord was disinfected with a 10.0% iodine solution as soon as possible after birth.

c. Milk production was checked in the ewes that lambed and labms were checked for colostrum ingestion within the first six hours of life. If these was any trouble related with milk production, adoption was tried or artificial nursing.

d. Lambs were weighed and identified by using aluminum eartags.

e. Lambs were docked by cauterizing pliers.

f. Lambs were given an A, D, and E vitamin injection.

After a week, lambs were allowed to go to pasture with the ewes until they reach 18-20 Kg. This usually happened when the lambs were close to three months old. At this time, the lambs were weaned.

In the second and third lamb crops, all the lambs were exposed to a creep feeding ration (see nutritional program).

Weaning

At weaning, lambs were drenched for the first time, and this practice continued every two months until 8 to 10 months of age when the lambs were sold.

Vaccinations

The whole flock was vaccinated every six months against acute pneumonia using a vacterine, which gives temporary protection.

Lamb Sale

Some of the lambs were sold as breeding stock and others as slaughter lambs. Because of this, lambs have been sold an many different ages; however, the basic plan was to sell the lambs before they were 10 months old.

Nutritional Program

The nutritional program was based on the 7 hectares with improved pastures under irrigation (Table VIII) and the use of corn silage and oat hay forage, as supplement, during the winter and dry season. The harvested forage was produced on the 12 hectares of dry land. However, due to shortage of water for irrigation, the forage from the pastures was not sufficient. Therefore, in addition to forage from the dry land, some other feed was purchased to maintain the sheep in acceptable condition.

TABLE VIII

COMPOSITION OF IMPROVED PASTURES

Grasses	Kg of Seed/Ha.
Perennial ryegrass (Lolium perenne)	25
Annual ryegrass (Lolium multiflorum)	15
Tall fescue (Festuca arundinacea)	6
Orchardgrass (Dactylis glomerata)	6
Total	52

Ewes, lambs and rams were allowed to go to the pasture for two to four hours daily, depending on the pasture condition. Supplemental feed was used, depending on the condition and physiological stage of the sheep. During some periods (heavy rain season) sheep did not go to the pastures. In this situation, forage was cut and given to the sheep in the pens.

The extra feed for adults was corn silage, chopped fresh corn, oat hay, dry hen litter and molasses.

Lambs, up to weaning, were exposed to a creep ration and after weaning they were given supplementary ration (Tables IX and X) which have been offered in addition to the pastures.

TABLE IX

CREEP FEEDING RATION

Ingredients	% in the Ration
Milo (ground)	42.6
Oat hay (chopped)	33.0
Hen litter (dry)	4.7
Cria vaquina*	14.2
Molasses	4.7
Additives	.5
Antibiotics	.3
Total	100.0

*Commercial feed used for dairy cattle with a minimum of 18% of crude protein.

Even though there are no records of consumption, it has been suggested (Whiteman, 1981 and 1982, personal communication), in visits made to the station, that sheep should be managed in a better nutritional program, as they were considered to be in inadequate body condition to produce near their potential.

TABLE X

LAMB SUPPLEMENTARY RATION

Ingredients	% in the Ration
Milo (ground)	18.0
Oat hay (chopped)	45.0
Hen litter (dry)	22.0
Cria vaquina*	9.3
Molasses	5.0
Additives	.5
Antibiotics	.3
Total	100.0

*Commercial feed used for dairy cattle with a minimum of 18% crude protein.

Data Studied

Both lambs and ewes were studied. Within the lambs data, birth weight (BWt) was recorded and lamb survival (LS) was calculated as the percentage of lambs that reached weaning time with each of the birth weights recorded. That percentage was considered the survival for each lamb within each birth weight recorded. Data from lambs born in 1982 and 1983 was available for this analysis.

It was possible to compare BWt and LS on the basis of source of dam (SD), type of birth (BT) and sex. Also, the relationship between LS and BWt was observed.

Data from lambs born in 1983 in regard to weaning weight (WWt) was recorded. Adjusted weaning weight at 90 days (AWWt) was calculated by linear interpolation with the formula: AWWT = (WWt - BWt/WD - BD) 90 + BWt, where WD is weaning date and BD is birth date. Also, average daily gain (ADG) was calculated for each of the lambs. AWWt and ADG were compared on the basis of SD, BT, and sex. The relationship between ADG and BWt was observed.

In the case of the ewes, data in regard to lamb production and lamb rearing was recorded during 1981, 1982, and 1983. Wool production, weight and length of the fleece was recorded for the same periods.

Adjusted fleece weight (AFW1, AFW2, and AFW3) and adjusted fleece length (AFL1, AFL2, and AFL3) were calculated and adjusted to 365 days.

Adjusted fleece weight and adjusted fleece length were compared on the basis of year of production (YR), SD, number of lambs born (NLB) and number of lambs reared (NLR).

Lambing patterns on the basis of year and SD were also observed.

In addition to BWt, LS, AWWt, ADG, AFW and AFL, percentage of ewes lambing (fertility), frequency of twinning and lambing rate per ewe exposed, were extimated for these sheep.

Statistical Analysis

Mean, standard deviation and standard error were calculated for BWt and LS on the basis of year, SD, BT, and sex. Mean differences and levels of significance were looked for by using t-test whenever two means were involved and Duncan's multiple-range test whenever more than two means were involved.

Mean, standard deviation and standard error were calculated for AWWt and ADG on the basis of SD, BT, and sex. Mean differences and levels of significance were looked for by using the same tests.

The regression coefficients of LS on BWt and ADG on BWt were calculated. The regression curve of LS on BWt was plotted.

Mean, standard deviation and standard error were calculated for AFW and AFL on the basis of year, SD, NLB, and NLR. Mean differences and levels of significance were observed by using t-test and Duncan's test in the way previously explained.

Frequency of ewes lambing on the basis of year and SD was also observed.

Estimates of percentages of ewes lambing (fertility), twinning frequency and lambing rate per ewe exposed were also calculated (Steel and Torrie, 1960).

CHAPTER IV

RESULTS AND DISCUSSION

This chapter is divided into three main sections: (a) analysis of lamb data; (b) analysis of wool production data; and (c) comments about the reproductive performance of Lincoln sheep in Mexico.

Analysis of Lamb Data

The lamb data available permitted the study of birth weight and lamb survival from birth to weaning (90 days). Records of year of birth, source of dam of the lamb, type of birth and sex were kept for each lamb during the second (1982) and third (1983) lamb crops. This permitted the comparisons of birth weight and survival rate in regard to those environmental factors (year of birth, source of dam, type of birth and sex). The relationship between the traits (birth weight and survival rate) also was analyzed.

In regard to weaning weight and average daily gain from birth to weaning (ADG), the data available (1983), permitted the comparison of the means of these traits on the basis of source of dam, type of birth and sex. Moreover, the relationship between adjusted weaning weight and birth weight was also analyzed.

A description of the analysis made of the observed traits as affected by each of the environmental factors is presented in the body of the text.

Birth Weight and Survival Rate as Affected by Year

The effect of year of birth has been mentioned as one of the normal and nonpredictable causes of variation in birth weight and survival rate of lambs. However, even though the effect of year of birth was not significant, the average birth weight for 1982 (4.53 ± .05 Kg) was 0.1 Kg heavier than for 1983 (4.43 ± .05 Kg) and the lamb survival rate for 1982 (91.1 ± .6%) was 1.2% greater than for 1983 (89.9 1 .7%).

For a better understanding of variation of birth weight and lamb survival throughout the years, analysis of data from several years should be made.

Birth Weight and Survival Rate as Affected by Source of Dam

The data considered in this analysis included 200 ewes obtained from the U.S., 98 ewes obtained from Australia and the first 20 ewe lambs selected and reared in Mexico.

Lamb birth weight means by source of dam were calculated and compared and are presented in Table XI. The birth weight of the lambs from the U.S. ewes (4.59 ± .04 Kg) was heavier than those from the Australian ewes (4.31 ±

.06 Kg) and this in turn was heavier than the Mexican ewe lambs (3.79 ± .21 Kg). These differences were significant.

TABLE XI

BIRTH WEIGHT AND SURVIVAL RATE OF LINCOLN LAMBS UNDER HIGHLAND MEXICAN CONDITIONS AS RELATED TO SOURCE OF DAM

Source of Dam		Birth Weight (Kg)	Survival Rate (%)
U.S.	(413)	$4.59 \pm .04^{a}$	91 ± 1^{a}
Australia	(205)	$4.31 \pm .06^{b}$	90 ± 2^{a}
Difference between U.S. and Australia		.28	1
Mexico	(16)	$3.79 \pm .21^{c}$	75 ± 11^{b}
Overall Average	(634)	4.48 ± .03	90 ± 1
Difference between U.S. and Mexico		.8	16

[abc]Numbers with different letter within columns are significantly different ($P < .05$).

In regard to lamb survival, lambs from the U.S. ewes (91 ± 1%) had a similar rate to that for lambs out of the Australian ewes (90 ± 1%). Lambs out of the Mexican ewes (75 ± 11%) showed a survival rate significantly lower than the other two.

Lambs out of the U.S. ewes, even though comparable to lambs out of the Australian ewes, have shown a tendency to have a greater survival rate.

The nutritional program was similar for the three groups of ewes. Consequently, the difference in birth weight and survival rate of the lambs out of the Mexican ewes was probably more due to age of the dam than any other factor. At that time, the Mexican ewes were yearlings, and all the imported ewes were mature ewes. In the case of the imported ewes, the difference between them could be due to chance or possible the genetic makeup of each group.

An analysis of birth weight and lamb survival as affected by age of dam was not possible since exact age of dam was not known for the imported ewes. However, a comparison between lambs out of yearlings (Mexican ewes) and lambs out of ewes older than three years (imported ewes) would be used in the comparison by source of dam.

Lambs out of yearlings were lighter at birth (3.79 ± .21 Kg) and their survival rate was lower (75 ± 11%) than those out of mature ewes (4.50 ± .04 Kg and 91 ± 1%) by .71 Kg and 16% respectively.

These results are in general agreement with those reported by Sidwell et al. (1964) and Eltawil et al. (1970). The former working with several breeds obtained an average birth weight of 3.3 Kg. for lambs born from yearling ewes and 3.6 Kg for lambs born from mature ewes. The latter author working with Navajo ewes reported an average birth weight of 3.2 Kg for lambs born from yearling ewes and 3.6 Kg for those born from mature ewes. Both authors mentioned that the survival was greater for lambs out of mature ewes; however, they did not show data referent to survival rate.

Birth Weight and Survival Rate as Affected by Type of Birth

There was a significant difference in birth weight between those lambs born as singles and those born as twins. Singles on the average (4.73 ± .04 Kg) were heavier than twins (3.97 ± .05 Kg) by .76 Kg (Table XII).

TABLE XII

BIRTH WEIGHT AND SURVIVAL RATE OF LINCOLN LAMBS UNDER HIGHLAND MEXICAN CONDITIONS AS AFFECTED BY TYPE OF BIRTH

Type of Birth		Birth Weight (Kg)	Survival Rate (%)
Single-born lambs	(428)	$4.73 \pm .04^{a}$	89 ± 1
Twin-born lambs	(206)	$3.97 \pm .05^{b}$	91 ± 1
Overall Average	(634)	4.48 ± .03	90 ± 1
Difference between single-born and twin-born lambs		.76	2

[ab]Numbers with different letter within columns are significantly different ($P < .01$).

These results are in agreement as far as general tendencies with those out of studies done by Blackwell and Henderson (1955) working with several breeds, reported a difference of .83 Kg in favor of those born as singles above twins; Sidwell et al. (1964) reported an average birth weight for several breeds of 4.18 Kg when born as singles and 3.27 Kg when born as twins. There was a difference in favor of the single of .91 Kg; Eltawil et al. (1970) found for Navajo sheep an average birh weight of 3.99 Kg for singles and 3.23 Kg for twins. There was a difference in favor of the singles of .76 Kg. In general, birth weight tends to decrease as number of lambs born per ewe increases (Brandford and Boylan, 1981) (Table IV).

In regard to survival rate, there was not a significant difference between single born lambs and twin born lambs. Moreover, twin born lambs survival rate (91 ± 1%) was a little higher (2%) than single born lambs survival rate (89 ± 1%) (Table XII).

These results are not in concordance with reports made by other authors. Brandford and Boylan (1981) reported a lamb survival rate of 89.1 ± 1.2% for single born lambs and 75.7 ± .09% for twin born lambs. In general, they said that lamb survival rate increases as number of lambs per ewe decreases (Table IV).

Birth Weight and Survival Rate as Affected by Sex

Male lambs showed a strong tendency to be heavier (4.55 ± .05 Kg) than females (4.41 ± .04 Kg); however, this difference was not significant.

The difference of .14 in favor of the males was in agreement with reports made by Blackwell and Henderson (1955), Sidwell et al (1964), and Eltawil et al. (1970). Those authors working with several breeds reported differences of .24, .23, and .20 Kg in favor of the males respectively. The range average of birth weight was from 3.49 to 4.07 Kg.

In regard to survival rate, females showed a greater survival rate (94 ± 1%) than males (86 ± 1%). This difference of 8% was significant (Table XIII).

This result is in agreement with those found in the literature. Brandford and Boylan (1981) reported a small difference in survival rate in favor of females (1%). Notter and Copenhaver (1980) reported also that the perinatal mortality rate appeared to be higher in males than in females.

Even though, on the average, those differences are not significant, there is some evidence that female lambs have greater ability to survive than males.

TABLE XIII

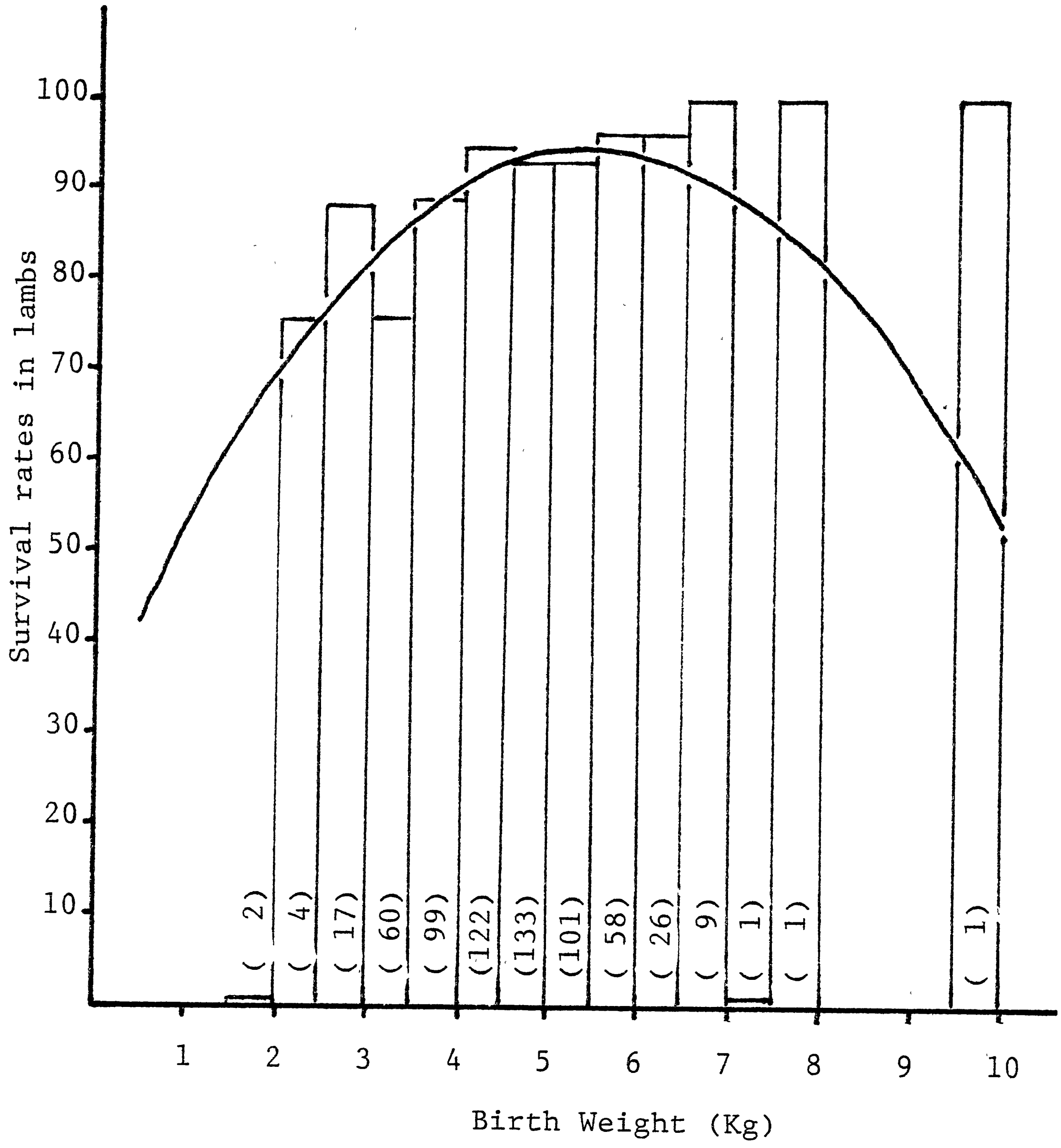
BIRTH WEIGHT AND SURVIVAL RATE OF LINCOLN LAMBS UNDER HIGHLAND MEXICAN CONDITIONS AS AFFECTED BY SEX

Sex		Birth Weight (Kg)	Survival Rate (%)
Male lambs	(310)	4.55 ± .05	86 ± 1[b]
Female lambs	(324)	4.41 ± .04	94 ± 1[a]
Overall average	(634)	4.48 ± .03	90 ± 1
Difference between male and female lambs		.14	8

[ab]Numbers with different letter within columns are significantly different ($P < .05$).

Relationship Between Survival Rate and Birth Weight

A quadratic effect was observed in the relationship between survival rate and birth weight ($P < .001$). As shown in Figure 5, the line that fits the data of this study indicates that survival rate in lambs was maximized at birth weights between 5 and 6 Kg. Mortality increased similarly as birth weight got heavier or lighter. However, the histogram in the same figure represents the actual survival rate in each of the birth weights. This histogram suggests that survival rate increased even after 6 Kg of birth weight. It seems that within the range of this study (1.4 - 9.9 Kg) lighter lambs at birth had less ability to survive.



Note: Numbers within parentheses are the number of lambs born within each interval of birth weight.

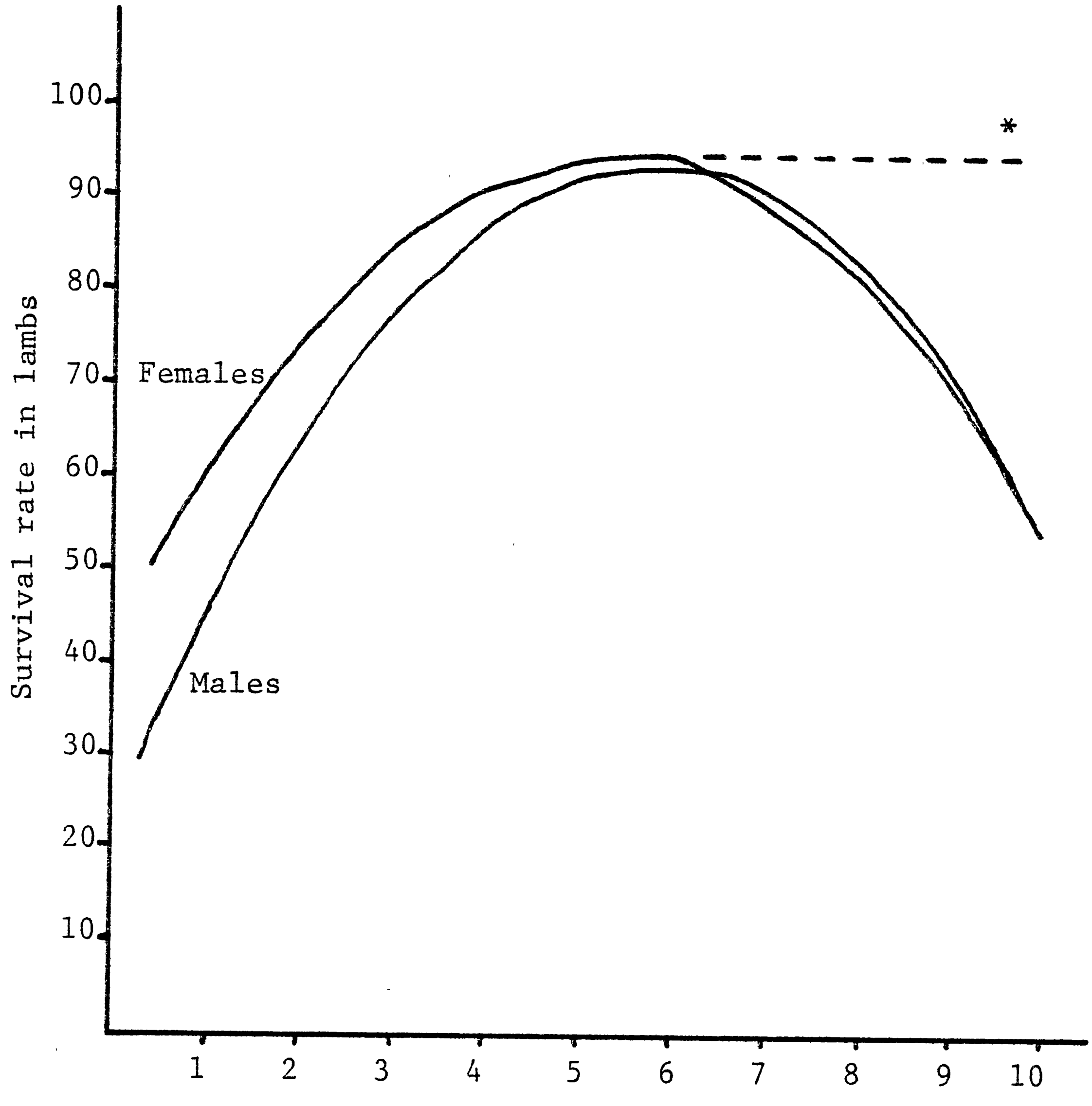
Figure 5. Relationship Between Lamb Survival and Birth Weight in Lincoln Lambs Under Highland Mexican Conditions

Since survival rate varied significantly between males and females, a regression of survival rate by sex on birth weight was made (Figure 6). As shown in Figure 6, the lines that fit our data suggest that survival in both sexes was similar when the lambs reached 5 or more Kg at birth. However, as birth weight decreased to less than 5 Kg, females showed more ability to survive. Moreover, as shown by the histogram of Figure 5, one of the sexes did not lose practically individuals after 6.5 Kg. Consequently one of the lines of Figure 6 (females) should be practically perpendicular to the survival rate axis, as presented by the dotted line in Figure 6. The literature suggests that the Lincoln data from Mexico was too small. We expect that later on our regression lines and our actual data will agree with the literature reports.

The results of the regression lines are in agreement with those reported by Notter and Copenhaver (1980), who found a similar quadratic effect in the relationship between perinatal mortality and birth weight. The smallest mortality occurred when lamb birth weights were between 5 and 6 Kg, and females tended to survive more than males (Figure 4).

Weaning Weight and ADG as Affected by Source of Dam

On the average, lambs born from the U.S. ewes (21.90 ± .39 Kg) weighed 1.98 Kg more at 90 day weaning than those born from the Australian ewes (19.92 ± .51 Kg), and 4.99 Kg



*Possible line for females according to the histogram in Figure 5.

Figure 6. Relationship Between Lamb Survival and Birth Weight in Male and Female Lincoln Lambs Under Highland Mexican Conditions

more than the ones out of the Mexican ewes (16.91 ± 1.21 Kg). These differences were significant.

In regard to ADG, lambs out of the U.S. ewes (.191 ± .004 Kg) had greater ADG by .019 Kg than the lambs born from the Australian ewes (.172 ± .005 Kg), and .046 Kg greater than those out of the Mexican ewes (.145 ± .013 Kg). The differences in ADG were significant also.

The most important feature in this part, is that there was a significant difference between the lambs produced by the imported ewes. There was evidence that, on the average, the U.S. ewes produced the heaviest lambs at weaning with the greatest ADG (Table XIV).

TABLE XIV

WEANING WEIGHT AND AVERAGE DAILY GAIN ON LINCOLN LAMBS UNDER HIGHLAND MEXICAN CONDITIONS AS AFFECTED BY SOURCE OF DAM

Source of Dam		Weaning Weight (Kg)	ADG (Kg)
U.S.	(170)	$21.90 \pm .39^{a}$	$.191 \pm .004^{a}$
Australia	(80)	$19.92 \pm .51^{b}$	$.172 \pm .005^{b}$
Difference between the U.S. and Australia		1.98	.019
Mexico	(11)	16.91 ± 1.21^{c}	$.145 \pm .013^{c}$
Difference between the U.S. and Mexico		4.99	.046
Overall average	(261)	21.08 ± .31	.184 ± .003

[abc]Numbers with different letter within columns are significantly different ($P < .05$).

Weaning Weight and ADG as Affected by Type of Birth

On the average single born lambs (21.77 ± .34 Kg) at weaning weighed 2.59 Kg more than twin born lambs (19.18 ± .64 Kg). In regard to ADG, single born lambs showed a greater ADG (.189 ± .003 Kg) than the twin born lambs (.170 ± .007 Kg) by .019 Kg (Table XV). These differences were significant.

The outcome of this analysis as far as general tendencies is in agreement with those reported by Hazel and Terrill (1945, 1946), Blackwell and Henderson (1955), and Eltawil et al. (1970). Those authors working with different breeds and weaning their lambs at different ages and under different conditions, reported that on the average, single born lambs were heavier at weaning than twin born lambs.

Weaning Weight and ADG as Affected by Sex

On the average, male lambs at weaning (21.50 ± .51 Kg) were heavier than females (20.79 ± .39 Kg) by .71 Kg; however, this strong evidence was not signicant. In regard to ADG, male lambs showed (.187 ± .005 Kg) a greater daily gain than females (.181 ± .004 Kg) by .006 Kg. The results are presented in Table XVI and are in agreement in general tendency with those reported by other authors.

TABLE XV

WEANING WEIGHT AND AVERAGE DAILY GAIN OF LINCOLN LAMBS UNDER HIGHLAND MEXICAN CONDITIONS AS AFFECTED BY TYPE OF BIRTH

Type of Birth		Weaning Weight** (Kg)	ADG* (Kg)
Single-born lambs	(192)	$21.77 \pm .34^{a}$	$.189 \pm .003^{a}$
Twin-born lambs	(69)	$19.18 \pm .64^{b}$	$.170 \pm .007^{b}$
Overall average	(261)	$21.08 \pm .31$	$.184 \pm .003$
Difference between single-born and twin-born lambs		2.59	.019

[ab]Numbers with different letter within columns are significantly different *($P < .05$), **($P < .01$).

TABLE XVI

WEANING WEIGHT AND AVERAGE DAILY GAIN OF LINCOLN LAMBS UNDER HIGHLAND MEXICAN CONDITIONS AS AFFECTED BY SEX

Sex		Weaning Weight (Kg)	ADG (Kg)
Male lambs	(109)	$21.50 \pm .51$	$.187 \pm .005^{a}$
Female lambs	(152)	$20.79 \pm .39$	$.181 \pm .004^{b}$
Overall average	(261)	$21.08 \pm .31$	$.184 \pm .003$
Difference between male and female lambs		.71	.006

[ab]Numbers with different letter within columns are significantly different ($P < .05$).

Hazel and Terrill (1945, 1946) reported a difference at weaning (120 days) in favor of the males of 3.76 Kg for Rambouillet and 4.89 Kg as an overall average of Corriedale, Columbia and Targhee breeds. Blackweel and Henderson (1955) found a difference of 1.98 Kg in favor of the males and an average weaning weight (90 days) of 28.30 Kg. Lindahl (1972) reported an ADG to 70 days for Finnsheep of .30 Kg and .21 Kg for males and females respectively.

Relationship Between Weaning Weight and Birth Weight

A definite relationship between weaning weight and birth weight was not found. Regression analysis of ADG and weaning weight on birth weight were done and the variation of birth weight did not produce a significant effect on either of them. These results are not in agreement with reports made by other authors, and there is no apparent reason for this situation; however, the low level of nutrition could have blocked the manifestation of the genetic potential of the lambs. In order to understand what caused this unexpected outcome, analysis of data from several years should be done or, if possible, specific trials should be run.

DeBaca et al. (1956) found that the main factor in variation of weaning weight was birth weight. They said that the range of increase in weaning weight varied from 2.42 to 5.96 Kg for each Kg of increase in birth weight.

Molina and Whiteman (unpublished) found that on the average, the increase at 70 days weaning weight was 2.42 Kg in the case of singles and 3.31 Kg in the case of twins for one Kg of additional birth weight.

Analysis of Wool Production Data

The data available, in regard to wool production, permitted the analysis of certain aspects of fleece weight and staple length. These two traits were the most important reasons for having imported Lincoln sheep to Mexico.

Fleece weight and staple length were analyzed on the basis of year of production, type of lambing and rearing, and source of the ewe.

Fleece Weight and Staple Length as Affected by the Year of Production

Data from three wool crops were analyzed. Fleece weight and staple length were adjusted to 365 day periods. Means of both traits were calculated for each year and compared. Adjusted fleece weight (AFW) and adjusted fleece length (AFL) were significantly different in each year (Table XVII).

Regardless of the unpredictable effect of the year on production, one of the factors in the variation of wool production from year to year could have been the age of the ewe.

TABLE XVII

ADJUSTED FLEECE WEIGHT AND ADJUSTED FLEECE LENGTH OF LINCOLN EWES UNDER HIGHLAND MEXICAN CONDITIONS, AS AFFECTED BY YEAR OF PRODUCTION

Item	Year 1	Year 2	Year 3
Adjusted fleece weight (AFW) (Kg)	(286) $6.50 \pm .06^a$	(279) $4.64 \pm .04^b$	(244) $4.38 \pm .03^c$
Adjusted fleece length (AFL) (cm)	(286) $19.84 \pm .14^a$	(279) $16.09 \pm .14^b$	(244) $15.52 \pm .09^c$

[abc]Numbers with different letter within columns are significantly different ($P < .01$).

Thrift and Whiteman (1969) reported that fleece weight declines as age of the ewe increases. Drummond, O'Connel and Colman (1982) reported that staple length decreases as age of the ewe increases. As Table XVII shows, while year of production (age of the ewe) increased, AFW and AFL decreased.

Adjusted Fleece Weight and Adjusted Fleece Length as Affected by Lambing and Rearing Type

The effect of lambing and rearing type was observed in each of the three crops. With the data available, three classes of sheep were available for this analysis: a group that did not become pregnant during that period; a group that produced and nursed one lamb; and a group of ewes that produced and nursed two lambs. The groups that produced one or two lambs and lost part or the complete litter, were not used for this analysis. Under these conditions, the evaluation of the effects of pregnancy and/or partial lactation on wool production was not possible. However, the effect of increasing lambing rate on wool production was observed in each of the crops.

During the first year, a significant difference in wool yield was observed between ewes that did not become pregnant (6.88 ± .14 Kg) and those that produced and nursed one (6.32 ± .08 Kg) or two (6.13 ± .26 Kg) lambs. During the second and third crops, there was no significant difference between the groups; however, on the average, the tendency for decreasing wool production as reproduction performance increased, was maintained during the three periods (Table XVIII).

These results agreed with those reported by Slen and Whiting (1956), who reported that ewes which gave birth to singles produced 19% more clean wool than the twin producers. They also said that this difference could be reduced by improving the nutritional program. Ray and Sidwell (1964) reported that ewes that gave birth to twins, singles or none lambs, produced 2.97, 3.19, and 3.52 Kg of grease wool respectively. Thrift and Whiteman (1969) reported that in Western ewes, the yield of clean wool declined slightly as number of lambs born and reared increased. They also said that in the case of Dorset this tendency was smaller.

In regard to staple length, there was not any significant difference due to reproductive variation in any of the years. Moreover, there was not any pattern or tendency to follow in the staple length of the fleece (Table XIX).

Adjusted Fleece Weight and Adjusted Fleece Length as Affected by Source of the Ewe

The Australian and the U.S. ewes were the ewes considered in this part of the analysis. The ewes from Australia, on the average, consistently produced heavier

TABLE XVIII

ADJUSTED FLEECE WEIGHT OF LINCOLN EWES UNDER HIGHLAND MEXICAN CONDITIONS AS AFFECTED BY TYPE OF LAMBING AND REARING AND YEAR OF PRODUCTION

Type of Lambing and Rearing	Adjusted Fleece Weight (Kg)					
	Year 1		Year 2		Year 3	
None producers	(55)	$6.88 \pm .14^{a}$	(19)	$4.86 \pm .14$	(4)	$4.54 \pm .25$
Single producers	(158)	$6.32 \pm .08^{b}$	(161)	$4.65 \pm .05$	(168)	$4.39 \pm .04$
Twin producers	(20)	$6.13 \pm .26^{b}$	(48)	$4.55 \pm .11$	(27)	$4.33 \pm .11$

[ab]Numbers with different letter within columns are significantly different ($P < .01$).

TABLE XIX

ADJUSTED FLEECE LENGTH OF LINCOLN EWES UNDER HIGHLAND MEXICAN CONDITIONS AS AFFECTED BY TYPE OF LAMBING AND REARING AND YEAR OF PRODUCTION

Type of Lambing and Rearing	Adjusted Fleece Length (cm)		
	Year 1	Year 2	Year 3
None producers	(55) 19.59 ± .28	(19) 16.36 ± .52	(4) 15.63 ± .98
Single producers	(158) 19.71 ± .18	(161) 15.92 ± .20	(168) 15.62 ± .11
Twin producers	(20) 20.64 ± .59	(48) 16.29 ± .41	(27) 15.38 ± .36

fleeces during the three crop period (6.84 ± .08, 4.78 ± .07, and 4.55 ± .04 Kg) than the ewes from the U.S. (6.33 ± .08, 4.58 ± .05, and 4.28 ± .04 Kg).

On the other hand, in regard to fleece length, the ewes from the U.S., on the average, produced longer fleeces the first two crops (20.40 ± .18 and 16.54 ± .17 cm) than the ewes from Australia (18.75 ± .16 and 15.22 ± .26 cm). However, in the last crop, the Australian ewes (15.80 ± .16 cm) produced longer fleeces than the U.S. ewes (15.36 ± .12 cm). All these differences were significant (Tables XX and XXI).

TABLE XX

ADJUSTED FLEECE WEIGHT OF LINCOLN EWES UNDER HIGHLAND MEXICAN CONDITIONS AS AFFECTED BY SOURCE OF THE EWE AND YEAR OF PRODUCTION

Year	Adjusted Fleece Weight (Kg)			
	Australia		U.S.	
1**	(97)	6.84 ± .08[a]	(189)	6.33 ± .08[b]
2*	(96)	4.78 ± .07[a]	(183)	4.58 ± .05[b]
3**	(91)	4.55 ± .04[a]	(153)	4.28 ± .04[b]

[ab]Numbers with different letter within row are significantly different *(P < .05), **(P < .01).

TABLE XXI

ADJUSTED FLEECE LENGTH OF LINCOLN EWES UNDER HIGHLAND MEXICAN CONDITIONS AS AFFECTED BY SOURCE OF THE EWE AND YEAR OF PRODUCTION

Year	Adjusted Fleece Length (cm)			
	Australia		U.S.	
1**	(97)	18.75 ± .16[a]	(189)	20.40 ± .18[b]
2**	(96)	15.22 ± .26[a]	(183)	16.54 ± .17[b]
3*	(91)	15.80 ± .16[b]	(153)	15.36 ± .12[a]

[ab]Numbers with different letter within row are significantly different *(P < .05), **(P < .01).

For a better understanding of the Lincoln wool production in Mexico, data of wool crops should be kept and analyzed for several years. This would help in selecting animals from this flock or importing new sheep from other countries, if wool continues being the basis for selection.

Comments About the Reproductive Performance of Lincoln Sheep in Mexico

It has been suggested in the literature, that moving ewes from one hemisphere to another affects the ovarian activity of the ewes (Yeates, 1949). This effect should depend more on the time of the year the sheep are moved than other factors. Also, Whitehurst (1947) and Hafez (1952) reported that moving sheep to different latitudes affected the ewes in their reproductive performance. For these reasons, it was interesting to observe the reproductive behavior of the Lincoln sheep brought from Australia (South hemisphere) and those brought from the U.S.

The Australian ewes were moved in late October (1980). At that time of the year, in the Southern hemisphere, the day length become longer. It is possible that the Australian ewes were in the final part of their breeding season; consequently, most of them may have been still cycling. These sheep arrived in Mexico in early November. The days in the North hemisphere at that time were shortening and consequently, the ewes were stimulated to continue cycling.

The Australian ewes were placed with the rams on December the 5th and the breeding season was extended until the end of February. Even though part of the ewes should have been cycling, the effect of the trip (15 days on ship) and body condition must have affected their reproductive performance. The fertility (percent of ewes lambing of ewes exposed to the rams) of the Australian ewes in this period was 64%.

In the case of the U.S. ewes, all of them were non-pregnant at arrival. They must have been affected by the change and the new conditions, since fertility rate (84%) was lower than the normal fertility (>90%) in Oregon.

The distribution of the conception date (Figure 7) in the first breeding season showed a big difference between

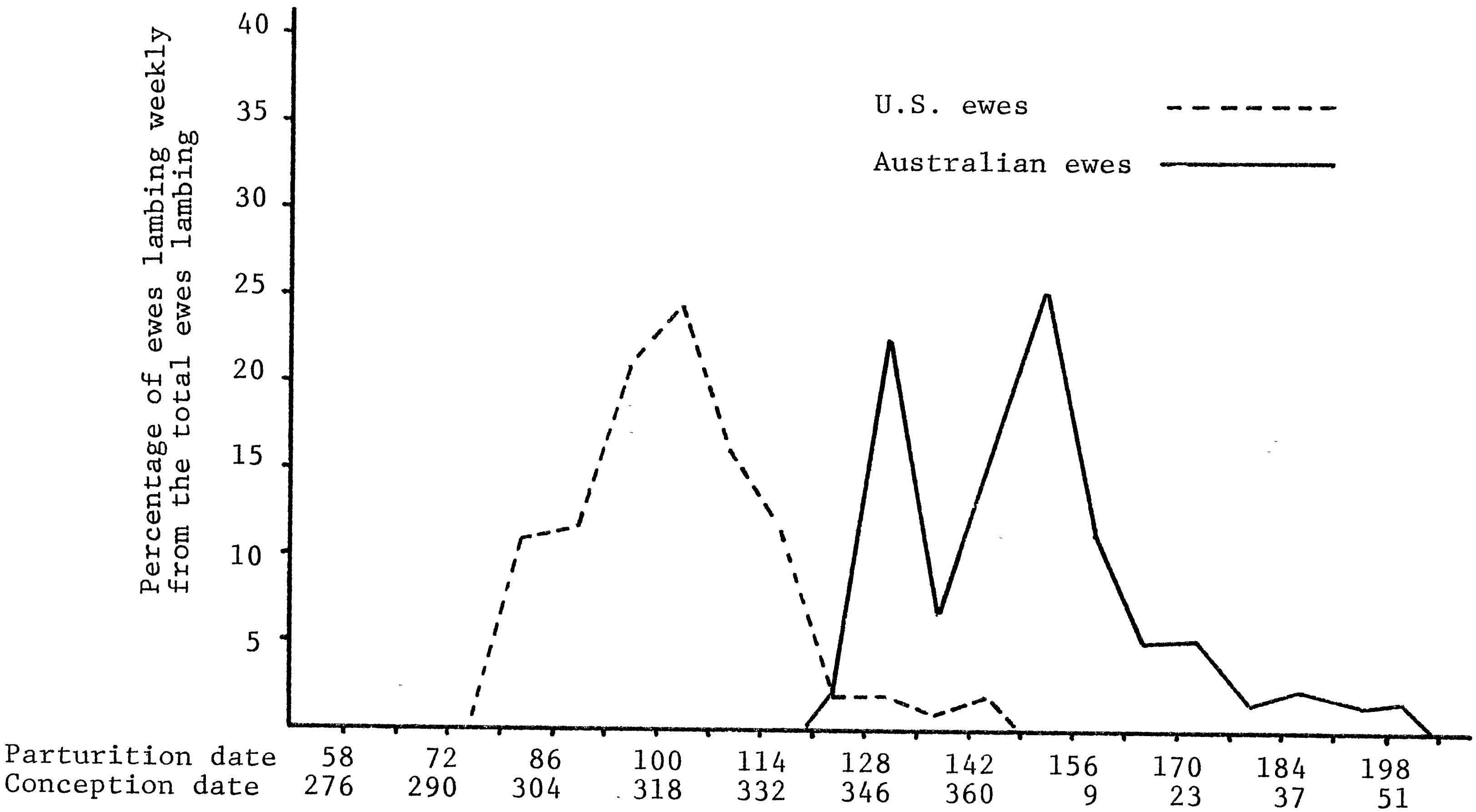


Figure 7. Distribution of the Conception Date of the Ewes Throughout the Year as Affected by Source of Dam (Expressed as Percentage of the Total Ewes in Each Group Lambing Each Week), Estimated by Subtracting 147 Days from the Day of Parturition (October 15, 1980-February 28, 1981)

the groups. This difference could have been due to physiological reasons; however, it has been thought that the main factor was the physical contact of the ewes with the rams.

Beginning with the second breeding season, the distribution of the conception date in both groups has been practically the same (Figures 8 and 9), and fertility as well has reached normal levels. The Australian group had 97.9% fertility rate while the U.S. group reached 89.8% in the second breeding season. In the last breeding season, the Australian group reached 93.7% and the U.S. group 91.2% of fertility.

Another important feature is that for reasons related to the availability of forage, the start of the breeding season has been moved one month earlier year by year. The reproductive performance of the ewes under those conditions has been acceptable. This does not tell us how the Lincoln sheep might perform when bred from March to July; however, it is helpful to know that the possibilities to succeed are good if the breeding season is scheduled from August 15 to February 15.

Fertility, frequency of twinning and lambing rate per ewe exposed to ram were estimated for these sheep and are presented in Table XXII. These traits were not compared by any statistical procedure.

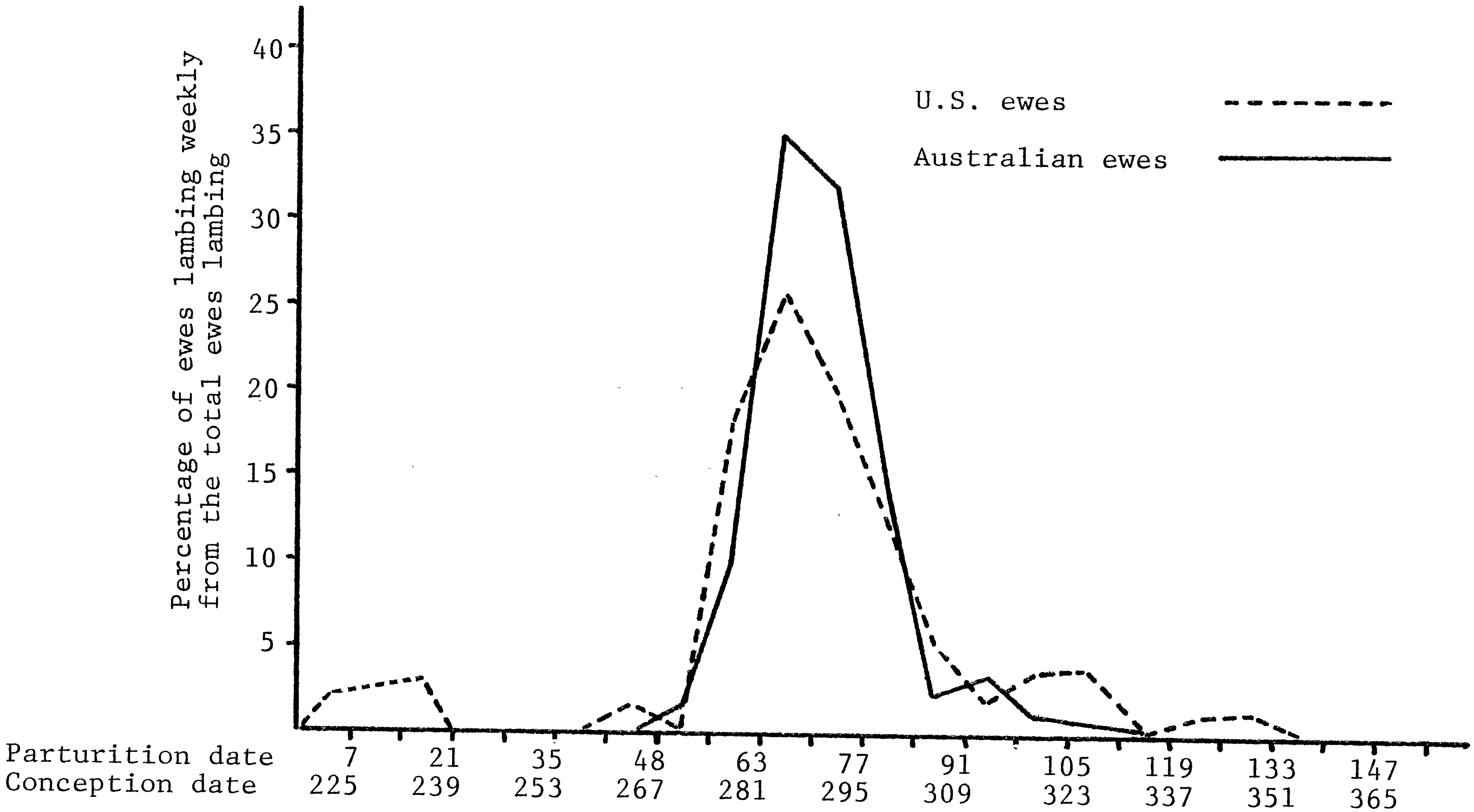


Figure 8. Distribution of the Conception Date of the Ewes Throughout the Year as Affected by Source of Dam (Expressed as Percentage of the Total Ewes in Each Group Lambing Each Week), Estimated by Subtracting 147 Days from the Day of Parturition (September 15, 1981-December 30, 1981)

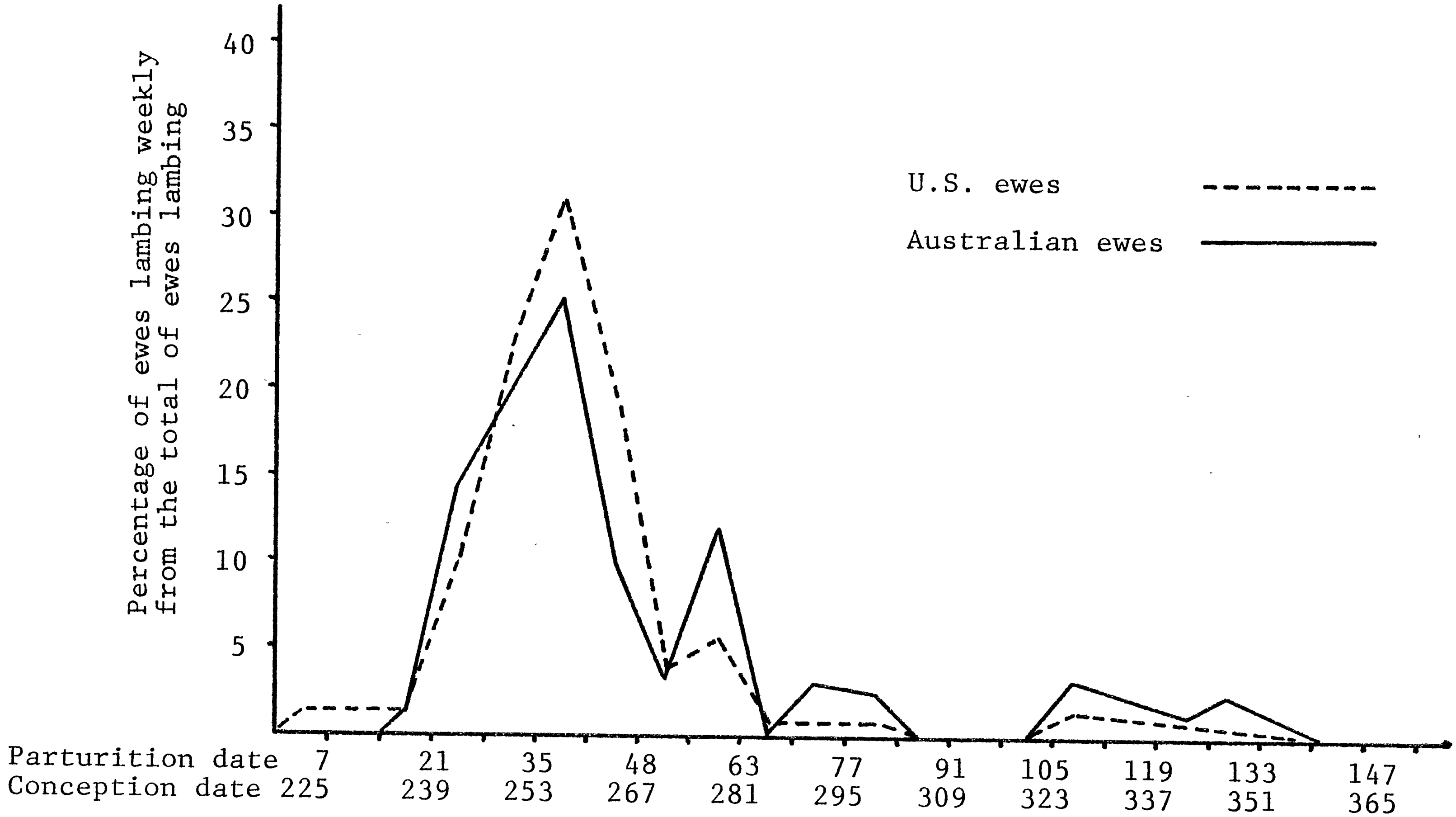


Figure 9. Distribution of the Conception Date of the Ewes Throughout the Year as Affected by Source of Dam (Expressed as Percentage of the Total Ewes in Each Group Lambing Each Week), Estimated by Subtracting 147 Days from the Day of Parturition (August 15, 1982-December 30, 1982)

TABLE XXII

FERTILITY, TWINNING FREQUENCY AND LAMBING RATE OF LINCOLN EWES UNDER HIGHLAND MEXICAN CONDITIONS THROUGHOUT A THREE YEAR PERIOD

Item	Year 1	Year 2	Year 3
Fertility (%)			
Complete flock	77.5	92.6	91.3
U.S. group	84.0	89.8	91.2
Australian group	64.0	97.9	93.7
Twinning frequency (%)			
Complete flock	14.2	25.8	15.3
U.S. group	18.4	30.1	19.8
Australian group	3.2	18.0	8.8
Lambing rate			
Complete flock	.85	1.11	1.05

CHAPTER V

SUMMARY

This study involves data from 298 Lincoln ewes imported from Australia (98) and the U.S. (200), 26 Lincoln rams and their lamb crops during a three year period under highland Mexican conditions.

Birth weight, survival rate at weaning, weaning weight (90 days) and ADG, were analyzed on the basis of source of dam, lambing type and sex. Lambs born from the U.S. ewes, were heavier (4.59 ± .94 Kg) than the ones from Australian ewes (4.31 ± .06 Kg) and these in turn heavier than the ones from younger Mexican ewes (3.79 ± .21 Kg) ($P < .05$). Single born lambs were heavier (4.73 ± .04 Kg) than twin born lambs (3.97 ± .05 Kg) ($P < .01$) and males showed a strong tendency to be heavier (4.55 ± .05 Kg) than females (4.41 ± .04 Kg).

In regard to survival rate at weaning, the U.S. group and the Australian group had similar survival rate (91 ± 1 and 90 ± 2% respectively) and those were greater than the survival rate showed by the yearling Mexican group (75 ± 11%) ($P < .05$). The single born lambs and twin born lambs had a similar survival rate (89 ± 1 and 91 ± 1%) and females (94 ± 1%) showed a greater survival rate than males

(86 ± 1%) ($P < .05$). In general, survival was maximized when the lambs had from 5 to 6 Kg at birth. Female lambs showed higher ability to survive than males, especially in birth weights smaller than 5 Kg.

Weaning weight and ADG showed similar tendency. On the average, the U.S. group had heavier weaning weights (21.90 ± .39 Kg) and greater ADG (.191 ± .004 Kg) than the Australian group (19.92 ± .51 Kg and .172 ± .005 Kg) and these in turn were greater than for the Mexican group (16.91 ± 1.21 Kg and .145 ± .013 Kg) ($P < .05$). As affected by type of birth, weaning weight and ADG were significantly greater for single born lambs (21.77 ± .34 Kg and .189 ± .003 Kg) than for twin born lambs (19.18 ± .64 Kg and .170 ± .007 Kg). Males at weaning showed a strong tendency to be heavier (21.50 ± .51 Kg) than females (20.79 ± .39 Kg), and the ADG for males (.187 ± .005 Kg) was greater than for females (.181 ± .004 Kg).

Weaning weight and ADG did not show an apparent relation with birth weight; however, the literature suggests a strong relationship between those traits.

In regard to wool production, adjusted fleece weight and adjusted fleece length were analyzed on the basis of year of production, type of lambing and rearing, and source of the ewes.

On the average, there were big differences in wool production (weight) (6.50 ± .06, 4.64 ± .04, and 4.34 ± .03 Kg) and staple length of the fleeces (19.84 ± .14, 16.09 ± .±4, and 15.52 ± .09 cm) during the three year period (1981, 1982, and 1983 respectively). Even though significant differences in wool production (weight) due to lambing and rearing type were manifested during the first year (6.88 ± .14, 6.32 ± .08, and 6.13 ± .26 Kg for none, single, or twin producers) the tendency to decrease wool production as reproductive rate increased was maintained in the three years.

In regard to staple length, there was no actual tendency to follow. As mentioned earlier there were significant differences among the different years, but not within the years.

As affected by the source of the ewes, on the average, the Australian produced significantly heavier fleeces (6.84 ± .08, 4.78 ± .07, and 4.55 ± .04 Kg) than the U.S. ewes (6.33 ± .08, 4.58 ± .05, and 4.28 ± .04 Kg) during the three year period (1981, 1982, and 1983 respectively).

In regard to fleece length, on the average, the U.S. ewes produced longer staple length during the first two crops (20.48 ± .18 and 16.54 ± .17 cm) than the Australian ewes (18.75 ± .16 and 15.22 ± .26 cm). However, in the last crop the Australian ewes produced longer fleeces (15.80 ± .16 cm) than the U.S. ewes (15.36 ± .12 cm) ($P < .05$).

In regard to reproductive performance, it was observed that Australian sheep were more affected (South hemisphere to North hemisphere) than the U.S. sheep (different latitude within the same hemisphere) when moved to Mexico. In the first lambing crop, fertility rate was lower (64.0%) for the Australian ewes than for the U.S. ewes (84.0%).

For the second lamb crop, fertility rate was much better, 97.9% for the Australian ewes and 89.8% for the U.S. ewes. In the third period, fertility rate was practically the same (93.7% for Australians and 91.2% for the U.S.).

Finally, it was suggested that the breeding season for Lincoln sheep in the highland Mexican conditions could be extended from August 15 to February 15 with good possibilities for success.

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2

VITA

Andres Molina Fonseca

Candidate for the Degree of

Master of Science

Thesis: PRODUCTIVITY OF LINCOLN SHEEP IN MEXICO (PRELIMINARY ANALYSIS)

Major Field: Animal Science

Biographical:

Personal Data: Born in Mexico, D.F., Mexico, January 13, 1949, the son of Inocencio Molina Vilchis and Blanca Fonseca de Molina; married Laura Gilda Vela, August 31, 1972; the father of two sons, Andres and Gabriel Molina Vela.

Education: Received the title of Ingeniero Agronomo Especialista en Zootecnia from the Universidad Autonoma Chapingo, February, 1974, with a major in Animal Science; completed requirements for the Master of Science degree at Oklahoma State University in July, 1984.

Experience: Project evaluation, Animal Husbandry Extention and Producers Organization, Banco de Mexico, S.A., April, 1974 to May, 1981.

Professional Organizations: Sociedad Agronomica Mexicana, Fraternidad Chapingo and American Society of Animal Science.